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FIXED-TIME SCHEDULE EFFECTS AS A FUNCTION OF BASELINE REINFORCEMENT RATE

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Using an arbitrary response, we evaluated fixed-time (FT) schedules that were either similar or dissimilar to a baseline (response-dependent) reinforcement schedule and extinction. Results suggested that both FT schedules and extinction resulted in decreased responding. However, FT schedules were more effective in reducing response rates if the FT reinforcer rate was dissimilar to baseline reinforcer rates. Possible reasons for this difference were evaluated with data analysis methods designed to identify adventitious response–reinforcer relations.

DESCRIPTORS: noncontingent reinforcement, fixed-time schedules, developmental disabilities

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A time-based schedule is defined as a schedule during which the reinforcer is delivered response independently on either a periodical (fixed-time, FT) or an aperiodical (variable-time, VT) schedule (Marr & Zeiler, 1974). Because time-based schedules disrupt response–reinforcer relations, the effects can be similar to extinction (Catania, 1969). That is, reinforcement depends on a contingency, and when FT or VT is implemented following a reinforcement baseline, a previously existing contingency is disrupted. However, procedurally, time-based schedules are distinguished from extinction in that the reinforcer is not withheld.

Further analysis of time-based schedules is needed for at least two reasons. First, factors responsible for the relation between time-based schedules and response reduction have not been clearly identified. For example, some laboratory research has shown that extinction is more effective than time-based schedules in reducing response rates (e.g., Lattal, 1972; Rescorla & Skucy, 1969). Conversely, there is evidence that under some circumstances FT schedules reduce response rates more effectively than extinction (Vollmer et al., 1998). In a study with nonhumans, Rescorla and Skucy found both VT and extinction resulted in decreased response rates, but extinction resulted in more immediate and larger decreases in behavior. Similarly, Lattal showed that FT and VT schedules following fixed-interval (FI) and variable-interval (VI) reinforcement sched-

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ules (i.e., baseline) resulted in decreased but stable response rates; extinction yielded less responding than FT or VT. By contrast, Vollmer et al. directly compared the effects of FT and extinction as treatment for the inappropriate behaviors of 3 individuals with developmental disabilities and found that FT was generally more effective than extinction in reducing problem behavior.

There are numerous procedural distinctions between laboratory and applied research evaluating time-based schedules. Some of these distinctions may be responsible for the seemingly discrepant results. One difference is that most laboratory studies involved time-based schedules that were yoked to baseline reinforcement rates (e.g., VI 2 min compared to VT 2 min; Rescorla & Skucy, 1969). Conversely, most applications of time-based schedules as treatment have involved schedules that are different from baseline. In fact, the schedule often involves continuous access to the reinforcer. An analysis of time-based schedules with similar versus dissimilar reinforcer rates (relative to baseline) may help to elucidate the factors that are responsible for clinical efficacy.

A second reason to study time-based schedules is related to methodology. Several recent studies have used analog preparations to study schedule effects. For example, Carr, Bailey, Ecott, Lucker, and Weil (1998) used an arbitrary block-placement response to evaluate the effects of reinforcer magnitude during FT schedules. Ecott, Foate, Taylor, and Critchfield (1999) also used arbitrary responses to evaluate FT effects. However, the reinforcer that maintained the arbitrary response was not demonstrated in either study. It is possible that block placement, for example, was maintained by instructions (implied or explicit) or by automatic reinforcement (e.g., response completion), and the reinforcer delivered during FT, therefore, was not related to baseline performance. To compare FT effects using arbitrary response preparations to treatment research using FT schedules, the reinforcer for baseline responding should be clearly identified (Ecott et al., 1999). The reason for this is that FT schedules, when used as treatment, usually involve delivering the reinforcer that had previously maintained problem behavior (e.g., Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993). In other words, the reinforcer delivered during FT is often the one that controlled response rates during baseline. Thus, when arbitrary (i.e., nonclinical) behaviors are the focus of the evaluation, a no-reinforcement baseline, an extinction condition, or both should be included in analyses of FT effects. Including such conditions will allow the experimenter to demonstrate that the reinforcer being tested is the one that maintained baseline responding.

Recent research concerning FT schedules and reinforcement schedules has been conducted using arbitrary responses (Carr et al., 1998). Results from these types of investigations may have clinical significance. Similar to extinction, time-based schedules result in decreased responding, which is important for addressing problem behavior such as aggression (Hagopian, Fisher, & Legacy, 1994) and self-injurious behavior (SIB; Vollmer et al., 1993). However, because little is known regarding the effect of various FT schedule densities, it may not be practical to study effects using clinically relevant behavior. Although it is important to continue to gather information regarding the effects of these schedules and this information may have application in the future, focusing on arbitrary behaviors may be the safest way to gain such information.

To date, no studies have systematically evaluated the relation between baseline and FT reinforcer rate. The main purpose of the current study was to evaluate the relations among baseline (response-dependent) reinforcer rate, different FT reinforcer rates (relative to baseline), and extinction. A second purpose of the study was to implement potential methodological refinements missing in previous FT investigations including a no-reinforcement baseline, an extinction condition, and data analysis techniques.

METHOD

Participants, Setting, and Apparatus

Twelve individuals were prescreened for participation in the study. Three individuals met the inclusion criterion (identification of a reinforcer for an arbitrary response as defined by higher response rates during a reinforcement condition relative to a preceding no-reinforcement baseline) and were able to complete the experiment. A 4th participant met the inclusion criterion but was excluded from the study because she was discharged from the facility where the study took place prior to completing the experiment.

Tami was a 4-year-old girl. She had a speech deficit and functioned in the mild to moderate range of mental retardation. She could speak in full sentences and had good receptive language. Jimmy was a 5-year-old boy who had been diagnosed with autism. He functioned in the moderate to severe range of mental retardation. Cathi was a 13-year-old girl who also functioned in the moderate to severe range of mental retardation. Both Jimmy and Cathi understood some basic signs (e.g., "more") and could follow one-step instructions. None of the participants was taking medication at the time of the study.

Sessions took place in a therapy room on an inpatient hospital unit. Two to eight 5-min sessions were conducted 4 to 7 days per week, depending on the participant's schedule (the exact procedures for each individual are described below). An experimenter was in the room along with a table, chairs, reinforcers (some conditions), and task materials. The room was equipped with a one-way mirror.

Specific task materials in the room varied across participants. Task materials included microswitches (for Jimmy and Cathi) that varied in color depending on experimental condition and component; for Tami, a slotted tray, colored blocks, and a placemat of varying color, depending on condition and component, were present.

Measurement

Trained psychology interns and bachelor's level therapists served as observers. All observations were conducted from behind a one-way mirror. Observers used the Observe computerized data-collection program to record target behavior, reinforcer delivery, and collateral behaviors (e.g., aggression). The computer program permitted data analysis to be made on a second-by-second basis.

For Jimmy and Cathi, the target behavior was activating a microswitch. For Tami, the target behavior was accurately sorting colored blocks. These behaviors are reported as number of responses per minute. Reinforcer delivery was also recorded and is reported as number of reinforcers per minute.

Agreement percentages were calculated based on 10-s interval-by-interval comparison of the observers' records, in which the smaller number of responses in each interval was divided by the larger number of responses. These fractions were then summed across all intervals, divided by the total number of intervals in the session, and multiplied by 100% to obtain the percentage agreement between the two observers (Vollmer et al., 1993). Interobserver agreement was collected by two independent observers during 24%, 26%, and 24% of Tami's , Jimmy's, and Cathi's sessions, respectively. Agreement for the target response averaged 98% (range, 85% to 100%) for Tami, 95% (range, 84%

to 100%) for Jimmy, and 95% (range, 78% to 100%) for Cathi.

Reinforcer Assessment and Experimental Designs

Reinforcer assessment. Prior to inclusion in the experiment, a brief preference assessment was conducted to determine potential reinforcers. For Tami, a free-operant preference assessment (Roane, Vollmer, Ringdahl, & Marcus, 1998) was conducted. For Jimmy and Cathi, potential reinforcers were selected based on parental nomination.

During a no-reinforcement baseline, each of the participants was given a task to complete with no reinforcer available for response completion. Each no-reinforcement baseline session lasted 5 min. When responding was stable across sessions, a response-dependent baseline condition was conducted. During the response-dependent baseline sessions (5-min duration), the stimulus selected via the preference assessment was presented on an FR 1 schedule. Increases in responding during the response-dependent baseline relative to the response-independent baseline were taken as indicative of a reinforcement effect, and the participant was included in the FT evaluation. Tami, Jimmy, and Cathi were the only participants for whom this criterion was met.

Experimental designs. Fixed-time schedules and extinction were evaluated using a combination of multielement and reversal designs (the particular designs employed varied across participants). When a multielement design was used, each component of the various phases was correlated with a unique stimulus (e.g., color of microswitch). Varying the color of the stimuli was intended to aid in discrimination among the schedules.

For Tami, a combination multielement and reversal design (ABACAD) was used, in which A = baseline (FR 1 vs. FR 1), B = FT 180 s (dissimilar) versus extinction, C = FT 20 s (similar) versus extinction, and D = FT 20 s (similar) versus FT 90 s (dissimilar). For Jimmy, a combination multielement and reversal design was initially used. However, to aid in discrimination, the design was changed to an ABCBCACADAD reversal design, in which A = baseline (FR 1), B = extinction, C = FT 10 s (similar), and D = FT 40 s (dissimilar). For Cathi, an ABABACA (C vs. B) reversal design was used, in which A = baseline (FI 30 s), B = FT 5 s (dissimilar), and C = FT 30 s (similar).

Procedure

Work materials were placed in front of the participant, and he or she was instructed as follows: "Here is a task to work on; you may do as much as you want, as little as you want, or none at all." The participant was then allowed to engage in the task for 5 min. At the end of the 5-min session, the therapist told the participant he or she was done. This procedure was followed for each of the conditions.

FR 1 baseline. Following the initial instruction, the therapist provided the reinforcer on an FR 1 schedule. At the end of a 5-min session, the therapist told the participant that he or she was done working. Once stable responding was observed across sessions, the experimental conditions were conducted. This FR 1 baseline condition is analogous to the baseline conditions described in many treatment studies, in which each occurrence of a target behavior results in reinforcer delivery (e.g., Vollmer et al., 1998).

FI baseline. Following demonstration of reinforcer effectiveness, Cathi's behavior was maintained on an FI 30-s reinforcement schedule. Following the initial instruction, the first response following 30 s was reinforced throughout each 5-min baseline session. At the end of the session, the therapist told Cathi she was done working. Once stable responding was observed across sessions, the experimental conditions were conducted.

The FI baseline condition was analogous to the baseline conditions described in previous studies (e.g., Rescorla & Skucy, 1969).

Extinction. In this condition, no reinforcers were available. Following the prompt to work, no reinforcers were presented, regardless of the participant's behavior. The purpose of the extinction condition was to provide a comparison to the FT conditions. Also, decreased responding in this condition would confirm that the reinforcer used in the experiment maintained the target response.

FT similar. This condition was designed to evaluate FT schedule effects when the programmed reinforcer rate was similar to that achieved during the preceding response-dependent baseline. Following the prompt to work, the therapist provided a reinforcer independent of responding at a rate yoked to the previous baseline schedule. If the response-dependent schedule was interval based (e.g., FI 30 s), the FT-similar schedule was FT 30 s. If the response-dependent reinforcer schedule was ratio based, the FT schedule was determined by calculating the average interreinforcer time of the last five sessions of the preceding response-dependent schedule. For example, if, on average, six reinforcers per minute had been delivered during the last five sessions of an FR 1 phase, the interreinforcer interval would be 10 s. Thus, the ensuing FT-similar schedule would be set at FT 10 s.

FT dissimilar. This condition was designed to evaluate FT schedule effects when reinforcers were delivered either more or less frequently than during the preceding response-dependent baseline. Following the prompt to work, the therapist provided a reinforcer independent of responding on a schedule that was dissimilar to the schedule in the previous condition. Dissimilar reinforcer rates were assigned by either multiplying or dividing baseline reinforcer rates by six. For example, if the last five sessions of the FR 1 baseline resulted in two reinforcers per minute (one every 30 s), the FT-dissimilar schedule would be either FT 5 s or FT 180 s. FT-dissimilar schedules following FI baselines were determined simply by multiplying or dividing the time component of the schedule by 6 s (e.g., FI 30 s would be changed to FT 5 s or FT 180 s).

RESULTS

The top panel of Figure 1 displays the results of the FT analysis for Tami. Following a response-dependent reinforcer baseline, the effects of an FT-dissimilar schedule and extinction were compared. Responding during the initial response-dependent baselines was reinforced on an FR 1 schedule. Rates averaged 1.5 responses per minute during the white component and 2.1 responses per minute during the black component. Following the FR 1 FR 1 baseline, an FT-dissimilar (180-s) schedule and extinction were implemented. Responding decreased during both components (M = 0.5 responses per minute during the last five sessions of the FT-dissimilar schedule and M = 0.4 responses per minute during the last five sessions of extinction). In both components, rates eventually reached zero. In addition, the degree to which mean response rates decreased from baseline was almost equivalent (76% decrease during the FT-dissimilar schedule and 73% decrease during extinction, based on the averages of the last five sessions in each component).

Following a reversal to a second FR 1 FR 1 baseline, the effects of an FT-similar schedule and extinction were compared. Initially, responding was variable during both schedules. During the last five sessions of the FT-similar schedule, responding averaged 2.4 responses per minute, and responding during the last five sessions of extinction averaged 0.5 responses per minute. When compared to the preceding FR 1 FR 1 con-

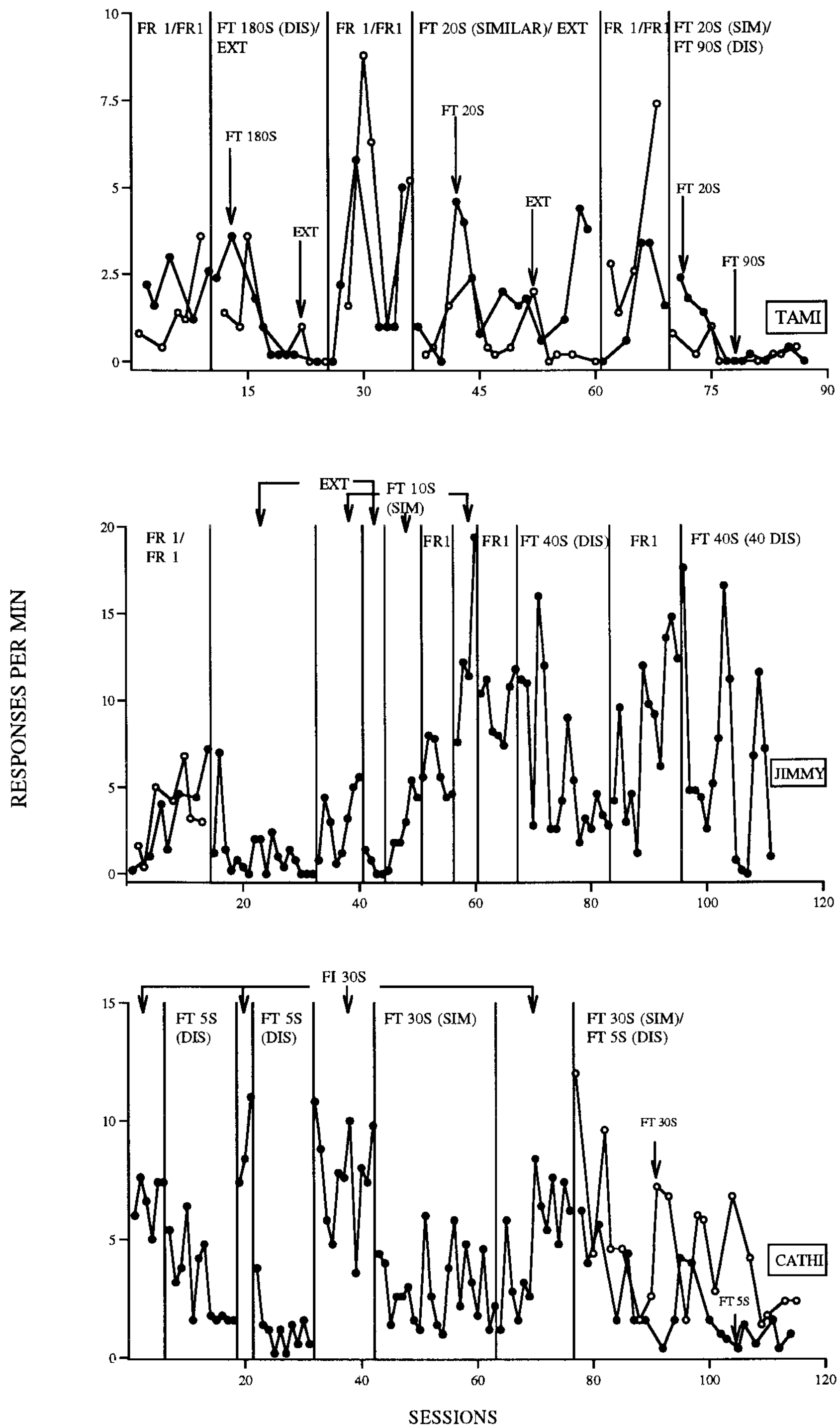

Figure 1. Number of responses per minute during response-dependent baseline (FR FI 30 s), FT similar, FT dissimilar, and extinction. For Tami, filled circles indicate when the black placemat was present, and open circles indicate when the white placemat was present. For Jimmy and Cathi, filled circles indicate when the blue microswitch was present, and open circles indicate when the yellow microswitch was present.

dition, these rates represent a 20% decrease during the FT-similar schedule and an 89% decrease during extinction. Following another reversal to FR 1 FR 1, FT-similar and FT-dissimilar schedules were directly compared. Responding in both schedules decreased to near zero (0.1 responses per minute during the last five sessions of the FT-similar schedule; 0.2 responses per minute during the last five sessions of the FT-dissimilar schedule). Thus, it appears that for Tami, under some situations, FT-similar schedules may result in response reduction. However, responding during the FT-dissimilar schedule was lower at the outset. To summarize, when FT-similar and FT-dissimilar schedules were compared to extinction, the FT-dissimilar schedule resulted in larger response decrements compared to the FT-similar schedule (76% vs. 20%). When compared directly, both FT-similar and FT-dissimilar schedules resulted in near-zero rates of responding, but the average reduction in the first five sessions was 39% during the FT-similar schedule and 86% during the FT-dissimilar schedule. Thus, overall, the FT-dissimilar schedule reduced response rates to a greater degree than did the FT-similar schedule, although both were successful in suppressing responding.

For Jimmy, we initially compared FT schedules to extinction as we did with Tami (not depicted in the figures). Although responding showed an extinction pattern during the extinction condition (both within and across sessions), the overall extinction effect was prolonged. We hypothesized that the alternation between FT and extinction schedules may have slowed the overall extinction effect; therefore, we changed the design to present each condition sequentially. The middle panel of Figure 1 displays the results of the sequential presentation of FR 1, extinction, FT-similar, and FT-dissimilar conditions for Jimmy.

During the first extinction condition, response rates dropped to near zero (M = 0.4 responses per minute during the last five sessions). During the FT-similar schedule, responding reemerged (M = 3.1 responses per minute during the last five sessions) despite the absence of a programmed reinforcement contingency. Because there appeared to be a reinforcement effect despite the absence of a planned contingency, we decided to replicate the effects before implementing an FT-dissimilar schedule. Extinction was reimplemented and response rates again dropped to near zero (M = 0.6 responses per minute). During the last five sessions of the following FT-similar schedule, response rates averaged 3.3 responses per minute. A new FR 1 baseline was implemented (M = 6.1 responses per minute during the last five sessions). An FT-similar (10-s) schedule was again implemented, and response rates increased across four sessions (M = 12.7 responses per minute, a 98% increase compared to the previous FR 1 baseline). During the last five sessions of the ensuing FR 1 schedule, response rates averaged 9.2 responses per minute. An FT-dissimilar schedule (40 s) was then implemented. During the last five sessions of this condition, response rates averaged 3.1 responses per minute (a 66% response reduction). An FR 1 schedule was then implemented. During the last five sessions of this condition, response rates averaged 11.2 responses per minute. An FT-dissimilar schedule (40 s) was again implemented. Responding during this schedule was highly variable compared to the earlier FT-dissimilar schedule. However, mean response rates decreased relative to the previous FR 1 schedule (M = 5.3 responses per minute during the last five sessions, a decrease of 53%). For Jimmy, when the various schedules were presented in a reversal fashion, response rates decreased during extinction (89% reduction) and FT dissimilar (60% reduction) when compared to the previous FR 1 schedule. Although some minimal response reduction was observed during the first two FT-similar evaluations, responding was on an upward trend in each. During the final evaluation of the FT-similar schedule, response rates were actually higher when compared to the previous FR 1 schedule. Although a different design was used, the results were similar to Tami's, insofar as FT-similar schedules did not decrease responding as effectively as FT-dissimilar schedules did.

The bottom panel of Figure 1 displays the results for Cathi. The effects of FT-dissimilar (5-s) and FT-similar (30-s) schedules were compared using an ABABACA (B vs. C) reversal design. Responding during the FI 30-s baseline averaged 6.8 per minute during the last five sessions. Responding during the first FT-dissimilar (5-s) schedule was initially similar to that of the previous FI baseline. However, responding decreased across sessions. During the last five sessions of the condition, response rates averaged 1.7 responses per minute (a 75% decrease from baseline). After a reversal to FI 30 s (M = 8.9 responses per minute), the FT-dissimilar schedule was reimplemented. Response rates decreased again, averaging 0.9 responses per minute during the last five sessions (a decrease of 90% from the previous FI 30-s schedule). Following another reversal to FI 30 s (M = 7.8 responses per minute during the last five sessions), an FT-similar schedule was implemented. Responding was highly variable and decreased relative to the previous FI 30-s schedule (M = 2.6 responses per minute during the last five sessions, a 67% decrease relative to the preceding baseline). Following another reversal to FI 30 s (M = 6.3 responses per minute during the last five sessions), the effects of FT-similar (30-s) and FT-dissimilar (5-s) schedules were compared using a multielement design. Responding decreased across both schedules. However, similar to the prior conditions, response rates during the FT-dissimilar schedule (M = 1 response per minute during the last five sessions, an 84% decrease) were reduced to a greater extent than during the FT-similar schedule (M = 2.4 responses per minute during the last five sessions, a 62% decrease). As with Tami and Jimmy, responding decreased to a greater extent during the FT-dissimilar schedules than during the FT-similar schedules.

In all three cases, FT schedules that were similar to the response-dependent reinforcer rate were less effective in reducing behavior than were dissimilar FT schedules. In one case (Jimmy), behavior actually increased during one FT-similar schedule evaluation. Intuitively, behavior should not be maintained during FT arrangements because no behavior is required to produce the reinforcer. However, there are several possible explanations for response maintenance during time-based schedules. Thus, we evaluated each participant's data in an effort to develop hypotheses about why behavior was sometimes maintained during FT arrangements.

One possibility is that the stimulus delivery "prompts" a response. For example, Uhl and Garcia (1969) showed that differential reinforcement was less effective than extinction in reducing lever pressing by rats. When the data from that study were analyzed on a molecular level, Uhl and Garcia found that lever presses occurred in close proximity to (almost immediately following) food delivery. Because extinction did not involve food delivery, none of these "prompted" lever presses occurred during the extinction condition. Because of this possibility of stimulus–response relations, we evaluated each of our participant's data by comparing the stimulus-independent probability of a response (the probability that a response would occur during some randomly selected time window) to the probability of a response given a stimulus (i.e., the conditional probability of a response during the time window after a stimulus delivery).

In no case did we find the sort of stimu-

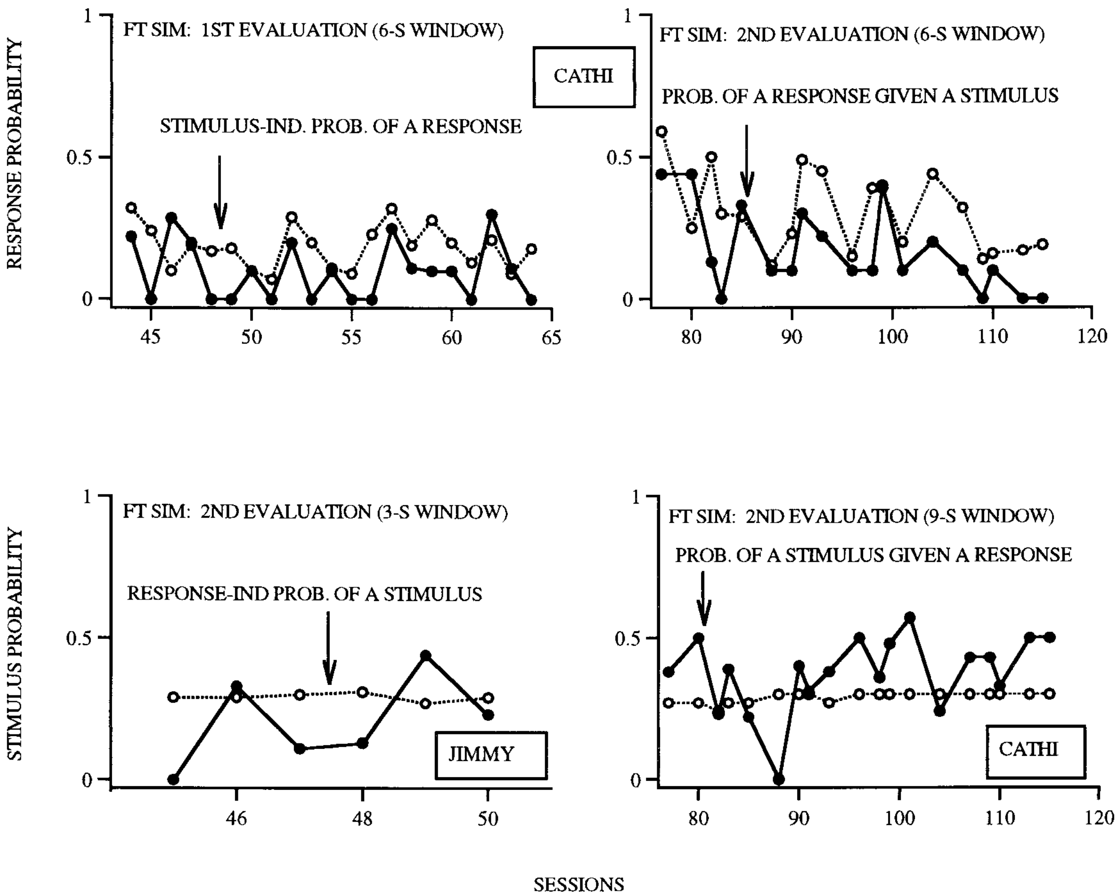

Figure 2. The top left and right panels display the probability of a response, either stimulus independent (open circles) or given a stimulus (filled circles), within 6 s during Cathi's FT-similar evaluations. The bottom left and right panels display the probability of a stimulus, either response independent (open circles) or given a response (filled circles), within 3 s during Jimmy's second FT-similar evaluation (bottom left) and within 9 s during Cathi's second FT-similar evaluation (bottom right).

lus–response relation described by Uhl and Garcia (1969). In fact, there was some evidence that participants paused after stimulus deliveries. The upper panel of Figure 2 displays the results of a stimulus–response analysis for Cathi. If stimulus presentation had no effect on responding, the data paths should map onto one another. If stimulus presentation increased the momentary probability of responding, the data path for the probability of a response given a stimulus should be higher than the stimulus-independent probability of a response. In both evaluations, the data path for the stimulus-independent probability of responding is higher than the data path for the probability of a response given a stimulus. These data show that Cathi was actually less likely to respond immediately (within 6 s) after a stimulus delivery.

A second possibility is that adventitious reinforcement contingencies emerged. For example, Vollmer, Ringdahl, Roane, and Marcus (1997) showed that aggressive responses occurred in close proximity to (preceding) stimulus deliveries on an FT schedule. The proximal relation between response and stimulus (i.e., response–stimulus relation) seemed to result in an accidental reinforcement effect. To evaluate the possibility of accidental reinforcement effects during FT-similar schedules, we calculated the response-independent probability of a stimulus compared to the response-contiguous probability of a stimulus. If the response-contiguous probability of a stimulus was higher than the response-independent probability of a stimulus, then a possible spurious relation is in effect. Albeit accidental, this response–stimulus relation is analogous to the necessary conditions for reinforcement effects: The conditional probability of a stimulus given a response is greater than the conditional probability of a stimulus given no response (Catania, Shimoff, & Matthews, 1987).

The only participant for whom we found evidence of a possible accidental response–stimulus relation was Cathi. The two lower panels of Figure 2 display representative examples of the stimulus analysis. The lower left panel shows the response-independent and response-contiguous probabilities of a stimulus (i.e., a stimulus given a response) for Jimmy. Note that the data paths show no clear difference between the two probabilities. The lower right panel, however, compares the two probabilities for Cathi. Note that the data path for the probability of a response-contiguous stimulus is higher than the data path for the probability of a response-independent stimulus.

It is understandable that Tami showed neither a stimulus–response relation nor a response–stimulus relation during the FT-similar condition, because her behavior in that condition was eventually extinguished. However, it is difficult to understand why Jimmy's data showed neither a stimulus–response relation nor a response–stimulus relation, given that response rates clearly persisted and even increased relative to baseline in the FT-similar schedule. Thus, a third possibility for behavioral maintenance may be considered. It is possible that behavior with a history of reinforcement in relation to a particular stimulus requires only intermittent pairings with that stimulus to maintain its response strength (i.e., a high rate of responding). There are two ways in which a preexisting contingency can be eliminated: (a) Sometimes behavior is still followed by a reinforcer (i.e., the schedule becomes more intermittent), and (b) sometimes the reinforcer occurs when no behavior occurs, but at other times it occurs contiguous to (following) a response. Thus, for Jimmy, we calculated the proportion of stimuli preceded by a response and the proportion of stimuli preceded by no response (the complement).

For each of the FT-similar schedule evaluations conducted with Jimmy, Figure 3 displays the evaluation of the proportion of stimuli preceded by a response within the previous 9 s or no response within the previous 9 s. As each FT-similar schedule progressed, the proportion of stimuli preceded by a response increased, as evidenced by the increasing trend in the data path. Further, the increase in the proportion of stimuli preceded by a response was accelerated by the third evaluation of the FT-similar schedule, to a point at which it exceeded the proportion of stimuli preceded by no response. Given a history of reinforcement (FR 1), such contiguous pairings may be sufficient to maintain responding adventitiously.

DISCUSSION

The relation between response-dependent baselines and FT schedules was evaluated. When FT schedules were similar to baseline reinforcer rates, response rates did not decrease as much as when FT schedules were dissimilar to baseline. In addition, for 2 participants, the response reduction during extinction was greater than the response reduction during FT-similar schedules but was roughly equal to the response reduction during FT-dissimilar schedules. These results suggest that schedule transitions from base-

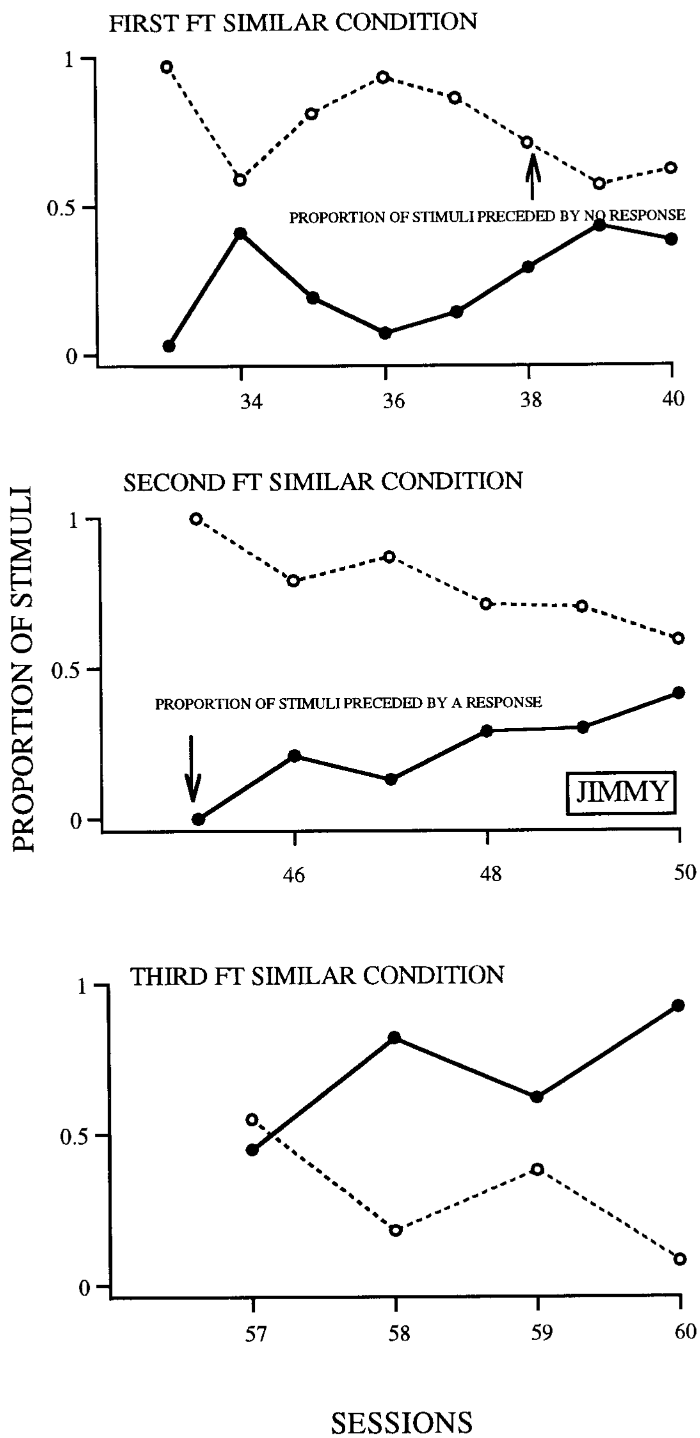

Figure 3. Proportion of stimuli preceded by no response (open circles) and preceded by a response (filled circles) within 9 s for each of Jimmy's FT-similar evaluations.

line to treatment are important. For example, when FT schedules are used as treatment, it may be beneficial to ensure that the reinforcer rate is distinct from baseline. However, because the behaviors evaluated were arbitrary (i.e., not clinically relevant), any extrapolation to problem behavior is tenuous and will require future research.

Hagopian et al. (1994) presented evidence that lean FT schedules were not as effective as rich FT schedules in reducing problem behavior. It is interesting to note that for Tami and Jimmy, FT-dissimilar schedules were more effective even though the schedule was much leaner (i.e., six times) than the FT-similar schedule. This result cannot be accounted for with a satiation interpretation, which would hold that, due to repeated delivery, the participants' responding was reduced because the reinforcers had lost efficacy. Although it could be argued that Cathi's behavior was affected by satiation, the results of this study are not wholly consistent with a satiation interpretation because higher rates of responding occurred during a relatively richer schedule (i.e., FT similar). If decreases in responding were a function of repeated reinforcer presentation (i.e., satiation), fewer responses should have been observed during the FT-similar schedules.

The results of this study also address one possible reason for the discrepant results in prior studies on time-based schedules. Specifically, prior research has shown that time-based schedules are less effective than extinction in reducing behavior (Lattal, 1972; Rescorla & Skucy, 1969). However, in those studies the time-based reinforcer rate was yoked to baseline. The current results suggest that time-based reinforcer rates that are distinct from baseline yield effects similar to extinction.

These results also have implications for treatment. If a practitioner recommends the use of noncontingent reinforcement to a parent of a child with a problem behavior without first knowing the existing reinforcement schedule for that behavior, the problem behavior may inadvertently be maintained or strengthened as a result of schedule similarity. The results of this study suggest that practitioners should take steps to ensure a discrepancy between baseline and treatment reinforcement schedules. This process might entail obtaining baseline reinforcement rates through naturalistic observation (e.g., Mace & Lalli, 1991). Fixed-time schedules could then be generated that would result in relatively more or less reinforcer delivery relative to baseline. An alternative approach would be to use an obviously discrepant schedule (e.g., continuous reinforcement) at treatment outset, as has been done in prior applications (e.g., Marcus & Vollmer, 1996; Vollmer et al., 1993; Vollmer, Marcus, & Ringdahl, 1995). A second implication for treatment is highlighted by Jimmy's results. Given the continuation of responding during FT schedules, the addition of brief differential reinforcement of other behavior (e.g., Vollmer et al., 1998) might be warranted. Adding this component would reduce the probability of adventitious reinforcement.

Another potential contribution of this study is methodological. There is a recent trend in applied behavior analysis to study basic reinforcement processes using arbitrary responses (e.g., Carr et al., 1998; Ecott et al., 1999; Vollmer & Iwata, 1991). Although it may seem obvious that such arbitrary responses are maintained by the programmed reinforcers being tested, we have seen numerous cases in which responding on a seemingly incidental task (e.g., button pressing) is maintained independent of programmed reinforcement. For example, several individuals who were screened for participation in this study continued to press a button even though it produced no extraneous reinforcer. It is possible that the behavior is automatically reinforced (e.g., response completion is reinforcing independent of the programmed contingency) or is under instructional control (including demand characteristics of the experimental environment). In this study, we included a no-reinforcement baseline to screen participants and an extinction condition for 2 participants to ensure that the programmed reinforcer was responsible for behavioral maintenance. Manipulating a stimulus that is not responsible for behavioral maintenance is likely to yield highly idiosyncratic outcomes in research on time-based schedules, in part because the behavior presumably continues to contact non-experimenter-specified reinforcement. Thus, the effects of the time-based schedule may depend on the presence of the uncontrolled automatic reinforcement contingencies.

There are some limitations to the current study. First, the reason that behavior was maintained during FT-similar schedules was not clearly identified for each participant. Our data suggest that factors influencing responding may be highly idiosyncratic. Evaluating relations between responding and subsequent stimulus deliveries can account for the maintenance of behavior during FT for Cathi and Jimmy. Further, the possibility of stimulus–response (i.e., "prompt") relations was ruled out in both cases. For Tami, response–stimulus and stimulus–response relations were not evident during the FT schedules, and it is therefore not surprising that her behavior eventually was extinguished.

The type of data analysis presented in this study provides a basis for future studies. The response–stimulus relations from baseline could be systematically altered to evaluate when and how those relations are disrupted. For example, the probability of a stimulus following behavior could be parametrically manipulated. Similarly, the proportion of stimuli presented in the absence of behavior could be manipulated experimentally and parametrically.

A second limitation of the current investigation is that all reinforcer schedules (response independent and dependent) were fixed (i.e., FR, FI, or FT). This type of schedule may not be analogous to the schedules that maintain behavior in the natural environment. Future studies could evaluate the effect of variable-ratio or VI schedules during baseline and ensuing VT schedules. For example, following stable baselines, FT and VT schedules (controlling for reinforcer rate) could be compared in order to identify relative efficacy. Although FT schedules have been demonstrated to be effective in reducing behavior in clinical settings (e.g., Vollmer et al., 1993), there have been few applied investigations evaluating VT schedules (cf. Mace & Lalli, 1991). Some basic research (e.g., Zeiler, 1968) has indicated that VT schedules can be more effective than FT schedules in reducing behavior. In addition, some applied studies have demonstrated that variable differential reinforcement schedules are effective in reducing behavior (Lindberg, Iwata, Kahng, & DeLeon, 1999). Thus, it may be that VT schedules would be more effective than FT schedules as treatment and may be more practical because care providers are unlikely to present reinforcers on a prescribed fixed schedule.

A third potential limitation is the arbitrary behavior evaluated. It is unclear if behaviors with long reinforcement histories, such as self-injury or aggression, would respond in a manner similar to the behaviors evaluated in the current study. Future research should focus on identifying the relations between reinforcement rate during response-dependent and response-independent (i.e., FT) reinforcement schedules as treatment for clinically relevant behavior.

Aside from the factors evaluated in the current study, there are numerous other parameters of time-based schedules that could be evaluated in future work (e.g., reinforcement history, reinforcer magnitude, variable vs. fixed schedules during both baseline and response-independent schedules), many of which have clinical relevance. For example, although FT reinforcement schedules have been demonstrated to reduce problem behavior (e.g., Vollmer et al., 1993), they require rigid adherence to a schedule. The presentation of reinforcers on a VT schedule may be more pragmatic for practitioners. However, there is currently no data to indicate how VT schedules could best be implemented. The methodologies provided in the current study may provide a basis for such an evaluation.

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STUDY QUESTIONS

1. Describe some advantages and disadvantages of studying arbitrary responses when evaluating the effects of time-based reinforcement schedules.

2. In what way are time-based (noncontingent) reinforcement schedules and extinction procedurally different yet functionally similar?

3. What were the criteria for participation as a subject in the study?

4. How were the similar and dissimilar FT schedules derived for each participant?

5. Summarize the results of the FT-similar and FT-dissimilar schedules for all 3 participants.

6. What factors might account for response maintenance observed under time-based schedules?

7. Which of the above factors most likely accounted for maintenance observed during Tami's initial multielement comparison of FT 20-s and extinction conditions? What type of data analysis and outcome would support such an explanation?

8. Describe some practical implications of the results obtained by this study.

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